(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 001 479 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.05.2000 Bulletin 2000/20

(51) Int Cl.7: **H01P 1/205**, H01P 1/213

(21) Application number: 99122518.6

(22) Date of filing: 11.11.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 13.11.1998 JP 32339298
13.10.1999 JP 29157499

(71) Applicant: Murata Manufacturing Co., Ltd.
Nagaokakyo-shi Kyoto-fu 617-8555 (JP)

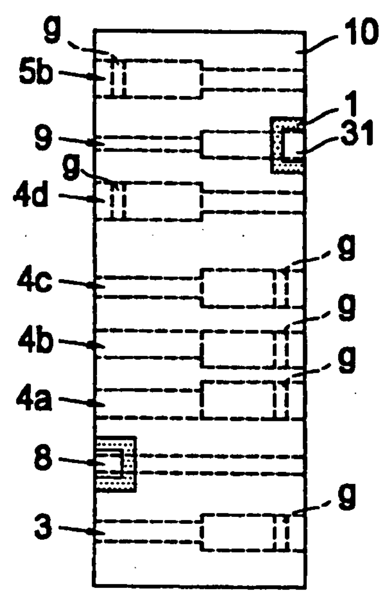
(72) Inventors:
- Tada, Hitoshi, (A170) Intellectual Prop. Dept. Nagaokakyo-shi, Kyoto-fu 617-8555 (JP)
- Hiroshima, Motoharu (A170) Intellectual Prop. Dept Nagaokakyo-shi, Kyoto-fu 617-8555 (JP)
- Kato, Hideyuki (A170) Intellectual Prop. Dept Nagaokakyo-shi, Kyoto-fu 617-8555 (JP)

(74) Representative: Schoppe, Fritz, Dipl.-Ing.
Schoppe, Zimmermann & Stöckeler
Patentanwälte
Postfach 71 08 67
81458 München (DE)

(54) **Dielectric filter, duplexer, and communication apparatus**

(57) There is disclosed a dielectric filter comprising: a plurality of resonant lines (4a-4d) disposed in a dielectric block (1), in a dielectric substrate, or on a dielectric substrate; wherein the open ends of at least one adjacent pair (4a-4c) of the resonant lines (4a-4d) are oriented in the same direction to be combline-coupled, a first trap-resonatcr resonant line (5a) and a signal inputting/outputting excitation line (9) are each interdigitally coupled to one (4d) of the plurality of resonant lines (4a-4d), and a second trap-resonator resonant line (5b) is interdigitally coupled to the excitation line (9).

Fig. 4A



Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a dielectric filter, a duplexer, and a communication apparatus incorporating the same, which are used in a high-frequency circuit.

2. Description of the Related Art

[0002] Dielectric filters having both band-pass characteristics and band-stop characteristics obtained by a plurality of resonant lines disposed in a dielectric block are disclosed in (1) Japanese Unexamined Patent Publication No. 8-32313 and (2) Japanese Unexamined Patent Publication No. 8-330806. In each of the dielectric filters, the plurality of resonant lines are combline-coupled in the dielectric block to obtain band-pass characteristics, and in addition, there is provide a trap resonator to form an attenuation pole.

[0003] Figs. 10A to 10D show an example of a duplexer using the conventional art. Figs. 10A to 10D are projection views of the duplexer, in which Fig. 10A is a front view, Fig. 10B is a left side view, Fig. 10C is a right side view, and Fig. 10D is a top view.

[0004] In this duplexer, holes and electrodes are formed with respect to a rectangular-parallelepiped dielectric block 1. Reference numerals 2 (2a, 2b, and 2c), 3, 4, (4a, 4b, 4c, and 4d), and 5 denote resonant-line holes, inside of which inner conductors are disposed to form resonant lines. Reference numerals 7, 8, and 9 denote excitation-line holes, inside of which inner conductors are disposed to form excitation lines. Reference numerals L1, L2 to Ld shown in the figure indicate serial numbers given to the above-mentioned lines in order to be referred to in an equivalent circuit shown below.

[0005] Fig. 11 is an equivalent circuit diagram of the duplexer shown in Fig. 10. In this figure, since Z12 acts a phase circuit of $\pi/2$ [rad] (hereinafter indicated by omitting the rad as a unit of a phase angle), (Z1 and Z12) act as trap resonators. Z3, Z4, and Z5 act as a three-stage resonator in which they are combline-coupled in sequence. Similarly, Z7, Z8, Z9, and Za act as a four-stage resonator in which they are combline-coupled in sequence. Additionally, since Zbc acts as a $\pi/2$ phase circuit, (Zc and Zbc) act as trap resonators.

[0006] Fig. 12 shows the pass characteristics of the duplexer described above. In this figure, the upper graph shows the pass characteristics of a reception filter, and the lower graph shows those of a transmitting filter. In the reception filter, signals of the receiving frequency band are allowed to pass through, whereas signals of the transmitting frequency band are attenuated, and in the transmitting filter, signals of the transmitting frequency band are allowed to pass through, whereas signals of the receiving frequency band are attenuated.

[0007] However, in the dielectric filters in accordance with the conventional art described in (1) and (2), although attenuation characteristics can be obtained by a polarity generated due to the coupling circuit of combline coupling and the single trap resonator, the depth (the amount of attenuation) of the polarity obtained by the coupling circuit cannot be changed. In addition, in order to bring the position of the polarity close to a pass band, it is necessary to narrow the pitch between the resonators (the distance between the resonant-line holes). However, if it is narrowed, Qo of the resonators is deteriorated.

[0008] Furthermore, in the dielectric filter according to the conventional art, the initial-stage or final-stage resonant line of the resonant lines being combline-coupled is coupled to the excitation line to obtain an external coupling, and the trap-resonator resonant line is adjacent to the excitation line, with the result that only a single attenuation pole can be obtained by the trap resonator.

SUMMARY OF THE INVENTION

[0009] To overcome the above described problems, one preferred embodiments of the present invention provides a dielectric filter comprising: a plurality of resonant lines disposed in a dielectric block, in a dielectric substrate, or on a dielectric substrate; wherein the open ends of at least one adjacent pair of the resonant lines are oriented in the same direction to be combline-coupled, a first trap-resonator resonant line and a signal inputting/outputting excitation line are each interdigitally coupled to one of the plurality of resonant lines, and a second trap-resonator resonant line is interdigitally coupled to the excitation line.

[0010] In this way, the adjacent specified ones of the plurality of resonant lines disposed in the dielectric block, the dielectric substrate, or on the dielectric substrate are combline-coupled, and at the part of the combline-coupling, band-pass filter characteristics are generated. In addition, the one of the plurality of resonant lines and the first trap-resonator resonant line are interdigitally coupled to produce a first attenuation pole, and the signal inputting/outputting excitation line and the second trap-resonator resonant line are interdigitally coupled to produce a second attenuation pole. Producing the first and second attenuation poles permits signals of a relatively wide frequency band to be largely attenuated, which leads to great improvement in the attenuation characteristics of the low-frequency side or high-frequency side in the pass band. In addition, since there is no influence of the pitch between resonators, widening the pitch between resonators can increase Qo, which leads to sufficient suppression of the insertion losses in the pass band.

[0011] Another preferred embodiment of the present invention provides a duplexer comprising a transmitting filter and a reception filter constituted of a plurality of

resonant lines disposed in a dielectric block, in a dielectric substrate, or on a dielectric substrate, at least one adjacent pair of the resonant lines being mutually coupled, wherein trap-resonator resonant lines are disposed to be interdigitally coupled to the final-stage resonant line of the reception filter and an excitation line coupled thereto or the initial-stage resonant line of the transmitting filter and an excitation line coupled thereto.

[0012] In this arrangement, the trap-resonator resonant lines for being interdigitally coupled to both the final-stage resonant line of the reception filter and the excitation line coupled to the resonant line are disposed so as to obtain reception filter characteristics having attenuation poles produced by the two trap-resonator resonant lines. In addition, the trap-resonator resonant lines for being each interdigitally coupled to both the initial-stage resonant line of the transmitting filter and the excitation line coupled to the resonant line are disposed so as to obtain transmitting-filter characteristics having attenuation poles produced by the two trap-resonator resonant lines. This permits the characteristics of the reception filter significantly attenuating the signals of the transmitting-frequency band to be easily obtained, and also permits the transmitting filter significantly attenuating the signals of the receiving-frequency band to be easily obtained.

[0013] That is, a duplexer can be produced where one of the transmitting filter and the reception filter or both of them having characteristics which significantly attenuate the frequency band of the counterpart filter.

[0014] Yet another preferred embodiment of the invention provides a communication apparatus by forming the dielectric filter or the duplexer described above in a high-frequency circuit section.

[0015] Using a compact filter or duplexer capable of passing the signals of a desired frequency band with low insertion losses to greatly attenuate the signals of the stopping frequency band permits a compact communication apparatus having an excellent high-frequency circuit characteristic to be produced.

[0016] Other features and advantages of the present invention will become apparent from the following description of the invention which refers to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0017] Figs. 1A, 1B, 1C and 1D are projection views of a duplexer according to a first embodiment of the present invention.

[0018] Fig. 2 is an equivalent circuit diagram of the duplexer.

[0019] Fig. 3 shows the pass-characteristic views of the reception filter and the transmitting filter used in the duplexer.

[0020] Figs. 4A, 4B, 4C and 4D are projection views of a dielectric filter according to a second embodiment of the invention.

[0021] Fig. 5 is an equivalent circuit diagram of the dielectric filter.

[0022] Figs. 6A, 6B, 6C and 6D are projection views of a dielectric filter according to a third embodiment of the invention.

[0023] Figs. 7A and 7B are sectional views showing a structure of lines according to a fourth embodiment of the invention.

[0024] Fig. 8 is a plan view of a duplexer according to a fifth embodiment of the invention.

[0025] Fig. 9 is a block diagram of a high-frequency circuit section used in a communication apparatus according to a sixth embodiment of the invention.

[0026] Figs. 10A, 10B, 10C and 10D are projection views of a conventional duplexer.

[0027] Fig. 11 is an equivalent circuit diagram of the conventional duplexer.

[0028] Fig. 12 is a pass-characteristic view of the conventional duplexer.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0029] A structure of a duplexer according to a first embodiment of the present invention will be illustrated referring to Figs. 1 to 3.

[0030] Figs. 1A to 1D are projection views of the duplexer, in which Fig. 1A is a front view, Fig. 1 B is a left side view, Fig. 1C is a right side view, and Fig. 1D is a top view. The front side shown in Fig. 1A is a surface for mounting the duplexer on a printed circuit board.

[0031] In this duplexer, holes and electrodes are formed with respect to a rectangular-parallelepiped dielectric block 1. Reference numerals 2 (2a, 2b, and 2c), 3, 4 (4a, 4b, 4c, and 4d), 5 (5a and 5b) denote resonant-line holes, inside of which inner conductors are disposed to resonant lines. Reference numerals 7, 8, and 9 denote excitation-line holes, inside of which inner conductors are disposed to form excitation lines. Inside of the resonant-line holes, electrodeless portions indicated by the symbol g are disposed to form open ends inside the holes. Reference numerals L1, L2 to Ld in the figure are series numbers given to the above-mentioned lines for being referred to in an equivalent circuit described below.

[0032] Reference numerals 6 (6a, 6b, 6c, 6d, and 6e) denote earth holes, the entire inner surfaces of which are disposed inner conductors. On the outer surface of the dielectric block 1, an outer conductor 10 is disposed in the region except terminal electrodes, which will be described below. The inner conductors of the earth holes 6 are electrically connected to the outer conductors of opposing both ends of the dielectric block 1.

[0033] A transmitting terminal electrode 27 is disposed at one end of the excitation-line hole 7. One end of the inner conductor of the excitation-line hole 7 is electrically connected to the transmitting terminal electrode 27, and the other end thereof is electrically connected to the outer conductor 10. An antenna terminal

electrode 28 is disposed at one end of the excitation-line hole 8. One end of the inner conductor of the excitation-line hole 8 is electrically connected to the antenna terminal electrode 28, and the other end thereof is electrically connected to the outer conductor 10. Similarly, a receiving terminal electrode 29 is disposed at one end of the excitation-line hole 9. One end of the inner conductor of the excitation-line hole 9 is electrically connected to the receiving terminal electrode 29, and the other end thereof is electrically connected to the outer conductor 10.

[0034] The operation of the duplexer having such a structure will be described as follows. First, the open ends of the resonant lines formed in the resonant-line holes 2a, 2b, and 2c are oriented in the same direction to be combline-coupled. The resonant line formed in the resonant-line hole 2c and the excitation line formed in the excitation-line hole 8 are interdigitally coupled. In addition, the resonant line formed in the resonant-line hole 2a and the excitation line formed in the excitation-line hole 7 are interdigitally coupled. Furthermore, the resonant line formed in the resonant-line hole 3 and the excitation line formed in the excitation-line hole 7 are interdigitally coupled. The earth hole 6a cuts off the coupling between the resonant lines of the resonant-line holes 3 and 2a. This allows the part between the transmitting terminal electrode 27 and the antenna terminal electrode 28 to serve as a transmitting filter having a single attenuation pole while passing the signals of a specified frequency band.

[0035] Furthermore, the open ends of the resonant lines of the resonant-line holes 4a, 4b, and 4c are oriented in the same direction to be combline-coupled. The resonant line of the resonant-line hole 4c and the resonant line of the resonant-line hole 4d are interdigitally coupled. The four resonant lines form a four-stage resonator so as to obtain a band-pass filter characteristic. The resonant line of the resonant-line hole 4d and the resonant line of the resonant-line hole 5a are interdigitally coupled. In addition to these, the resonant line of the resonant-line hole 4d and the excitation line of the excitation-line hole 9 are interdigitally coupled. The earth holes 6c and 6d cut off the coupling between the resonant lines of the resonant-line holes 4c and 5a, and the earth hole 6e cuts off the coupling between the resonant lines of the resonant-line holes 5a and 5b. In this arrangement, the resonant line of the fourth-stage resonant-line hole 4d and the excitation line of the excitation-line hole 9 form a $\pi/2$ phase circuit, and the respective resonant lines of the resonant-line holes 5a and 5b serve as trap resonators, in which the two trap resonators are phase-coupled at $\pi/2$. Therefore, the part between the antenna terminal electrode 28 and the receiving terminal electrode 29 serves as a reception filter having attenuation poles produced by the two trap resonators while passing the signals of a specified frequency band.

[0036] Fig. 2 is an equivalent circuit diagram of the duplexer shown in Fig. 1. In this figure, reference numerals such as Z1, Z2, and the like, correspond to the series numbers of the lines shown in Fig. 1. For example, reference numeral Z1 corresponds to the line L1 shown in Fig. 1 and the reference numeral Z2 corresponds to the line L2 shown in Fig. 1. In addition, impedance indicated by giving a one-digit number such as Z1 and Z2 is impedance of the self capacity of the resonant line and the excitation line, and impedance indicated by giving a two-digit number such as Z12 and Z23 is impedance of the mutual capacity generated between the coupled resonant lines or between the resonant line and the excitation line. For example, reference numeral Z12 corresponds to the mutual capacity between the lines L1 and L2, and reference numeral Z23 corresponds to the mutual capacity between the lines L2 and L3.

[0037] In this situation, when the self capacity of the resonator is represented by the symbol Ci, the mutual capacity of the resonator is represented by the symbol Cij, the relative permittivity of the dielectric block is represented by the symbol εr, and the velocity of light is represented by the symbol vc, the following equations are generally obtained.

$$Zi = \sqrt{(\varepsilon r)} / (vc \cdot Ci)$$

$$Zij = \sqrt{(\varepsilon r)} / (vc \cdot Cij)$$

[0038] In Fig. 2, Z12 acts as a $\pi/2$ phase circuit, and (Z1 and Z12) thereby act as trap resonators. Z3, Z4, and Z5 act as a three-stage resonator, in which they are combline-coupled in sequence. Z7, Z8, Z9, and Za act as a four-stage resonator in which they are coupled in sequence. In addition, since each of Zac and Zbd acts as a phase circuit of an electric length $\pi/2$ at a frequency which produces each attenuation pole, (Zc and Zac) and (Zd and Zbd) act as trap resonators. Since Zab acts as a $\pi/2$ phase circuit between the trap resonators, there is provided a structure in which the two trap resonators are connected to the reception filter.

[0039] Fig. 3 shows the pass characteristics of the duplexer. The upper graph shows the pass characteristics of the reception filter, and the lower graph shows the pass characteristics of the transmitting filter. This is an example of a communication system in which the low-frequency side is used as a transmitting frequency band and the high-frequency side is used as a receiving frequency band. In the reception filter, the signals of the receiving frequency band are passed, and the signals of the lower-frequency side, which is the transmitting frequency band, are attenuated by the two attenuation poles. This characteristic makes the attenuation curve of the lower-frequency side of the pass band steep and increases the attenuation in the transmitting frequency band, with the result that interference with the receiving

circuit caused by the signals of the transmitting-frequency band can sufficiently be suppressed.

[0040] In the present invention, since there is no need to dispose an attenuation pole by the polarity of the coupling circuit as describe above, for example, in order to bring the attenuation-pole frequency close to a pass band, it is unnecessary to narrow the pitch between the resonators (the distance between the resonance-line holes). Accordingly, widening the pitch between the resonators permits Qo (Qodd) to be greatly improved, and insertion-loss characteristics can thereby be improved.

[0041] In the first embodiment, although the two trap resonators are disposed in the reception filter, the trap resonators can also be disposed in the transmitting filter. More specifically, it is possible to dispose trap-resonator resonant lines, which are interdigitally coupled to the excitation line coupled to the initial-stage resonant line of the transmitting filter and the resonant line.

[0042] Next, a structure of a dielectric filter in accordance with a second embodiment of the present invention will be illustrated referring to Figs. 4A to 4B and 5.

[0043] Regarding the dielectric filter, the reception filter of the duplexer shown in Fig. 1 is taken out, and to the input-end side of the filter, another trap resonator is added. More specifically, in the dielectric filter, a plurality of holes and electrodes is disposed in a rectangular parallelepiped dielectric block 1. Reference numerals 3, 4 (4a, 4b, 4c, and 4d), 5 (5a and 5b) denote resonant-line holes, inside of which inner conductors are disposed to form resonant lines. Reference numerals 8 and 9 denote excitation-line holes, inside of which inner conductors are disposed to form excitation lines. Inside of the resonant-line holes, electrodeless portions indicated by the symbol g are disposed to form open ends. In addition, reference numeral 6 (6a, 6c, 6d, and 6e) denote earth holes, on the entire inner surfaces of which inner conductors are disposed. On the external surface of the dielectric block 1, an outer conductor 10 is disposed on the region except terminal electrodes. The inner conductors of the earth holes 6 are electrically connected to the outer conductors at the opposing ends of the dielectric block 1.

[0044] An input terminal electrode 30 is disposed at one end of the excitation-line hole 8. One end of the inner conductor of the excitation-line hole 8 is electrically connected to the input terminal electrode 30, and the other end thereof is electrically connected to the outer conductor 10. Similarly, an output terminal electrode 31 is disposed at one end of an excitation-line hole 9. One end of the inner conductor of the excitation-line hole 9 is electrically connected to the output terminal electrode 31, and the other end thereof is electrically connected to the outer conductor.

[0045] Fig. 5 is an equivalent circuit diagram of the dielectric filter shown in Figs. 4A to 4D. Each line indicated by the symbol of impedance is the equivalent to that in the case of the first embodiment. In Fig. 5, since Z16 serves as a $\pi/2$ phase circuit, (Z1 and Z16) serve as trap resonators. The parts of Z7 to Za serve as a four-stage resonator in which they are sequentially coupled. The structure of the output side (the right side in the figure) from Z9a is the same as that in the case of the first embodiment. Thus, the dielectric filter has a structure in which a total of three trap resonators are connected to a reception filter. When the resonant frequencies of these trap resonators are appropriately set, a band pass filter can be obtained where frequency signals of the high-frequency side or low-frequency side of the pass band or both sides thereof are steeply attenuated.

[0046] Next, the structure of a dielectric filter in accordance with a third embodiment will be illustrated referring to Figs. 6A to 6D.

[0047] Although the first and second embodiments adopt the arrangement in which the outer conductor is disposed on the open surfaces of the resonant-line holes of the dielectric block, and inside of the resonant-line holes, the electrodeless portions are disposed to form open ends inside the holes, the third embodiment has an arrangement such that the open end of each resonant line is disposed on the open surface of each resonant-line hole of a dielectric block. Furthermore, in the first and second embodiments, the excitation lines are disposed to be coupled to the resonant lines. In the third embodiment, however, terminal electrodes are formed on the outer surface of the dielectric block to be coupled to the resonant lines.

[0048] Figs. 6A to 6B are projection views of a duplexer in accordance with the third embodiment, in which Fig. 6A is a front view, Fig. 6B is a left side view, Fig. 6C is a right side view, and Fig. 6D is a top view. The front side shown in Fig. 6A is the surface for being mounted on a printed circuit board.

[0049] In this duplexer, holes and electrodes are formed with respect to a rectangular parallelepiped dielectric block 1. Reference numerals 2 (2a, 2b, and 2c), 3, 4 (4a, 4b, 4c, and 4d), 5 (5a and 5b) denote resonant-line holes, inside of which inner conductors are disposed to form resonant lines. Referential numeral 9 denotes an excitation-line hole, inside of which an inner conductor is disposed to form an excitation line. On the outer surface of the dielectric block 1, an outer conductor 10 is disposed in the region excepting the parts of open-end electrodes and terminal electrodes, which will be described below. In this arrangement, each one end of the resonant-line holes and each one end of the excitation-line holes are the short-circuited ends of the resonant lines and the excitation lines. In addition, on the open surface of the other end of each resonant-line hole, an open-end electrode extending in a quadrangular form is disposed.

[0050] Reference numerals 6 (6c, 6d, and 6e) denote earth holes, on the entire inner surfaces of which inner conductors are disposed. The inner conductors of the earth holes 6 are electrically connected to the outer conductors at the opposing ends of the dielectric block 1.

[0051] Reference numeral 27 denotes a transmitting

terminal electrode, which is disposed near the openings on the open-end sides of the resonant-line holes 2a and 3. Reference numeral 28 is an antenna terminal electrode, which is disposed near the openings on the open-end sides of the resonant-line holes 2c and 4a. A receiving terminal electrode 29 is disposed at one end of the excitation-line hole 9, and one end of the inner conductor of the excitation-line hole 9 is electrically connected to the receiving terminal electrode 29.

[0052] Basically, the operation of the duplexer having such a structure is the same as that shown in the first embodiment. More specifically, the resonant lines formed inside the resonant-line holes 2a, 2b, and 2c are coupled by the capacitance between the open-end electrodes of the respective resonant lines. The resonant lines formed inside the resonant-line holes 2a and 3 and the transmitting terminal electrode 27 are coupled by the capacitance between them. Similarly, the resonant lines formed inside the resonant-line holes 2c and 4a and the antenna terminal electrode 28 are coupled by the capacitance between them. In this arrangement, the part between the transmitting terminal electrode 27 and the antenna terminal electrode 28 serves as a transmitting filter having a single attenuation pole which allowing the signals of a specified frequency band to pass through.

[0053] Furthermore, the resonant lines of the resonant-line holes 4a, 4b, and 4c are coupled by the capacitance between the open-end electrodes of the resonant lines. The operations of the resonant-line holes 4c, 4d, 5a, 5b, and the earth holes 6c and 6e are the same as those in the first embodiment shown in Fig. 1. Under this situation, the resonant line of the fourth-stage resonant-line hole 4d and the excitation line of the excitation-line hole 9 form a π/2 phase circuit, the resonant lines of the resonant-line holes 5a and 5b serve as trap resonators, in which the two trap resonators are phase-coupled at π/2, As a result, the part between the receiving terminal electrode 29 and the antenna terminal electrode 28 serves as a reception filter having attenuation poles produced by the two trap resonators while passing the signals of a specified frequency band.

[0054] In the embodiments described above, holes are formed in the rectangular parallelepiped dielectric block and inside of the holes are disposed inner conductors to form the resonant lines, the excitation lines, and the earth lines. Alternatively, these lines can be formed by laminating dielectric substrates. Figs. 7A and 7B show sectional views of the lines in an example using such an arrangement. Fig. 7A is a sectional view of two sheets of dielectric substrates before lamination, and Fig. 7B is a sectional view thereof after lamination. Under this situation, lines are formed in the dielectric substrate by forming grooves in dielectric substrates 21a and 21b to dispose inner conductors on the inner surfaces of the grooves and laminate the two dielectric substrates 21a and 21b.

[0055] The resonant lines, the excitation lines, and the earth lines may be formed on the dielectric substrate. Fig. 8 shows an example of a duplexer using the arrangement. In Fig. 8, reference numeral 21 denotes a dielectric substrate, on which are formed resonant lines12a, 12b, 12c, 13a, 14a, 14b, 14c, 14d, 15a, and 15b. In addition, excitation lines 17, 18, and 19 are also formed thereon. In this case, the resonant lines 12a, 12b, and 12c serve as λ/2 resonators, in which both ends of the lines are open and the lines are combline-coupled. The resonant line 12a and the excitation line 17 are interdigitally coupled, and the excitation line 17 and the resonant line 13 are also interdigitally coupled. Moreover, the resonant line 12c and the excitation line 18 are also interdigitally coupled. In this arrangement, the part between a Tx terminal and an ANT terminal exhibits characteristics in which the band-pass filter characteristics of the resonant lines 12a, 12b, and 12c and the band-stop filter characteristics of the trap circuit of the resonant line 13 are combined.

[0056] In Fig. 8, the resonant lines 14a, 14b, and 14c serve as λ/2 phase circuits, in which both ends thereof are open, and they are combline-coupled. The resonance line 14c and the resonant line 14d are interdigitally coupled, and the resonant line 14d and the excitation line 19 are interdigitally coupled. In addition, the resonant line 14d and the resonant line 15a are interdigitally coupled, and the excitation line 19 and the resonant line 15b are interdigitally coupled. In this arrangement, the part between the ANT terminal and an Rx terminal exhibits characteristics in which the band-pass filter characteristics constituted of the resonant lines 14a, 14b, and 14c, and 14d and the band-stop filter characteristics constituted of the two trap circuits of the resonant lines 15a and 15b are combined.

[0057] Next, the structure of a communication apparatus using the dielectric filter or the duplexer described above will be illustrated referring to Fig. 9. In this figure, the symbol ANT denotes a transmitting/receiving antenna, the symbol DPX denotes a duplexer, the symbols BPFa, BPFb, and BPFc denote band-pass filters, the symbols AMPa and AMPb denote amplifying circuits, the symbols MIXa and MIXb denote mixers, the symbol OSC denotes an oscillator, and the symbol DIV denotes a frequency-divider (a synthesizer). The MIXa modulates frequency signals outputted from the DIV by modulation signals, the BPFa allows the frequency signals of only the transmitting frequency band to pass through, and the AMPa power-amplifies the signals to transmit from the ANT via the DPX. The BPFb allows the signals of only the receiving frequency band among the signals outputted from the DPX to pass through and the AMPb amplifies the passed signals. The MIXb mixes the frequency signals outputted from the BPFc and the receiving signals to output intermediate-frequency signals IF.

[0058] As the duplexer DPX shown in Fig. 9, it is possible to use the duplexer of the structure shown in Fig. 1. In addition, as the band-pass filters BPFa, BPFb, and BPFc, the dielectric filter of the structure shown in Fig. 40. In this way, the size of an overall communication ap-

paratus can be reduced.

[0059] While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the forgoing and other changes in form and details may be made therein without departing from the spirit of the invention.

Claims

1. A dielectric filter comprising:

   a plurality of resonant lines (2a-2c; 3; 4a-4d) disposed in a dielectric block (1), in a dielectric substrate, or on a dielectric substrate;

   wherein the open ends of at least one adjacent pair (2a-2c; 4a-4c) of the resonant lines (2a-2c; 3; 4a-4d) are oriented in the same direction to be combline-coupled, a first trap-resonator resonant line (5a) and a signal inputting/outputting excitation line (9) are each interdigitally coupled to one (4d) of the plurality of resonant lines (2a-2c; 3; 4a-4d), and a second trap-resonator resonant line (5b) is interdigitally coupled to the excitation line (9).

2. A duplexer comprising a transmitting filter and a reception filter constituted of a plurality of resonant lines (2a-2c; 3; 4a-4d) disposed in a dielectric block (1), in a dielectric substrate, or on a dielectric substrate, at least one adjacent pair (2a-2c; 4a-4c) of the resonant lines (2a-2c; 3; 4a-4d) being mutually coupled, wherein trap-resonator resonant lines (5a; 5b) are disposed to be interdigitally coupled to the final-stage resonant line (4d) of the reception filter and an excitation line (9) coupled thereto or the initial-stage resonant line (2a) of the transmitting filter and an excitation line (7) coupled thereto.

3. A communication apparatus having one of the dielectric filter in accordance with Claim 1 in a high-frequency circuit section thereof.

4. A communication apparatus having one of the duplexer in accordance with Claim 2 in a high-frequency circuit section thereof.

Fig. 1D

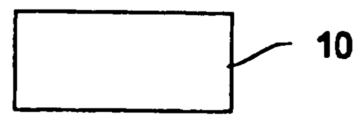


Fig. 1B

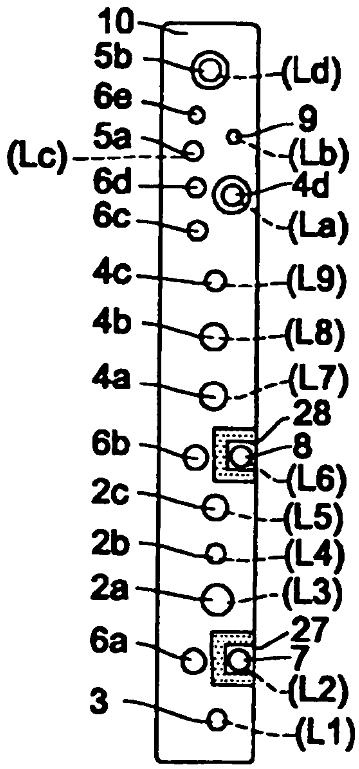


Fig. 1A

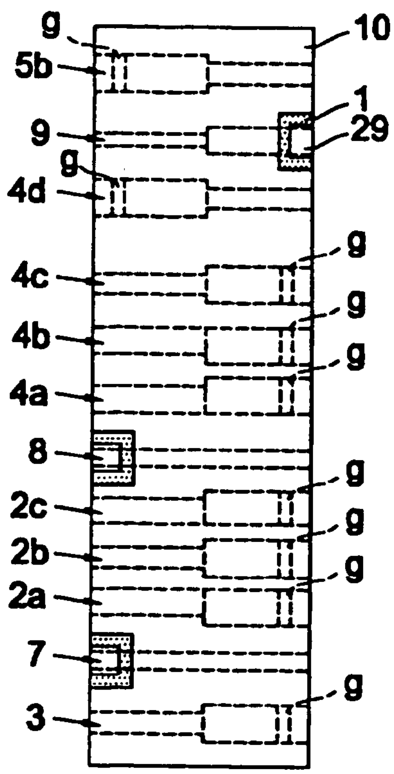
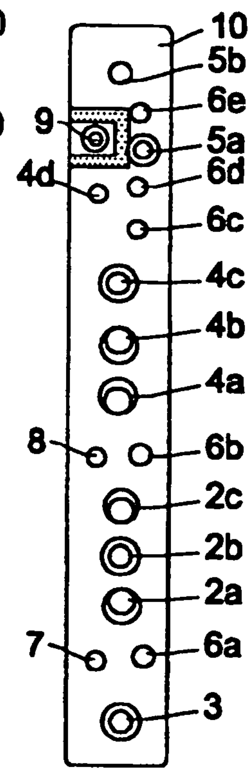


Fig. 1C



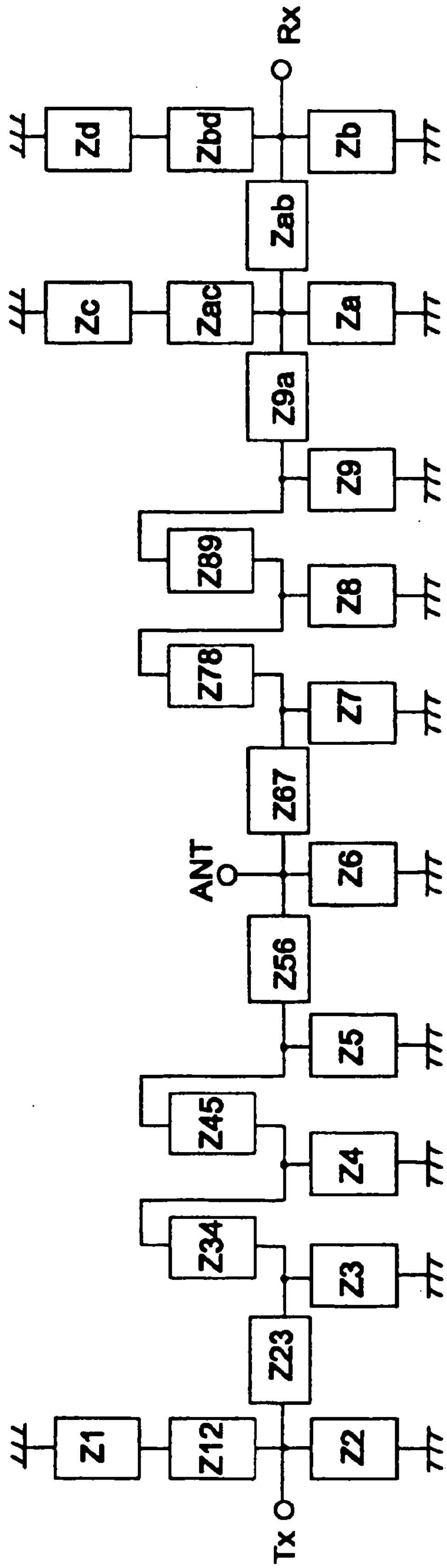

Rx
Zd
Zbd
Zb
Zab
Zc
Zac
Za
Z9a
Z9
Z89
Z8
Z78
Z7
Z67
ANT
Z6
Z56
Z5
Z45
Z4
Z34
Z3
Z23
Z1
Z12
Z2
Tx

Fig. 2

Fig. 3

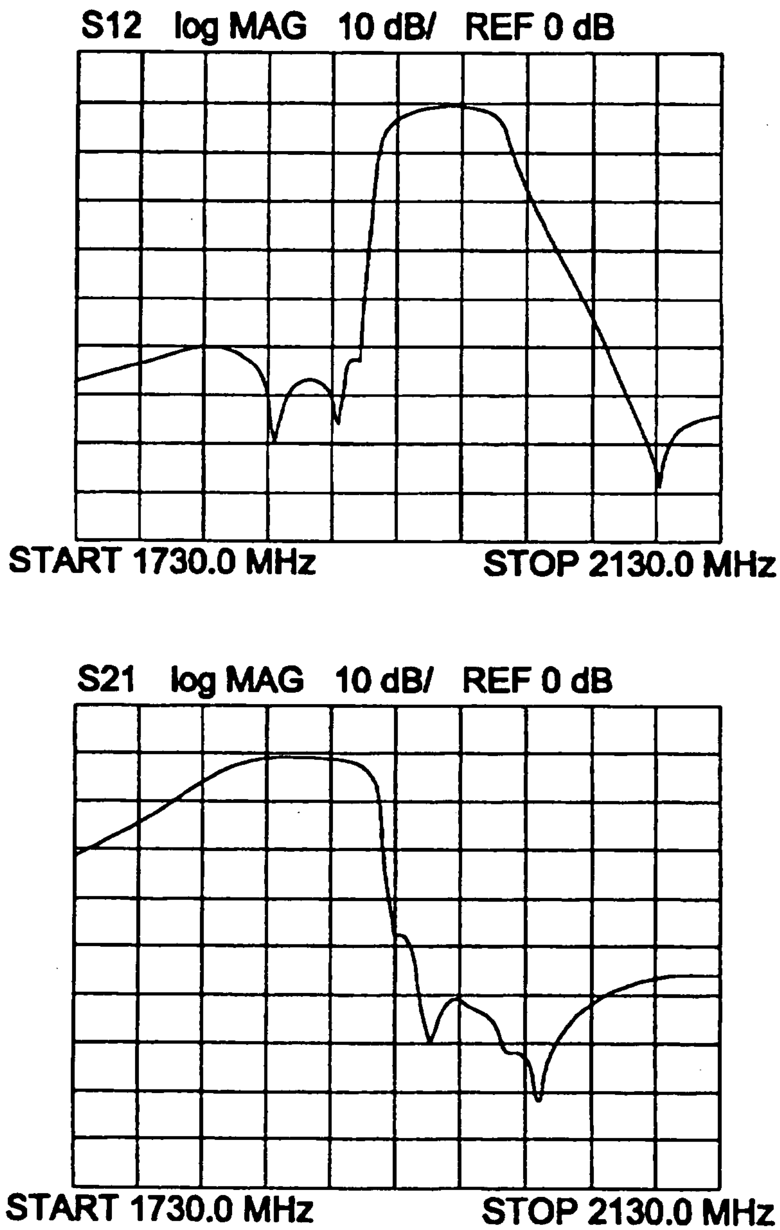

S12 log MAG 10 dB/ REF 0 dB
START 1730.0 MHz
STOP 2130.0 MHz
S21 log MAG 10 dB/ REF 0 dB
START 1730.0 MHz
STOP 2130.0 MHz

Fig. 4D

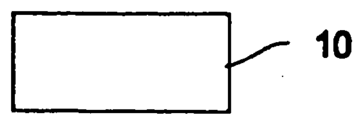


Fig. 4B

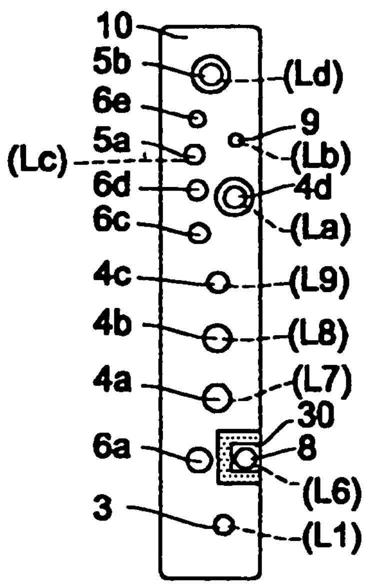


Fig. 4A

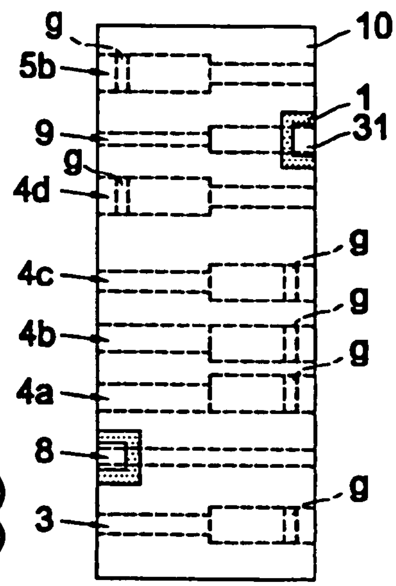


Fig. 4C

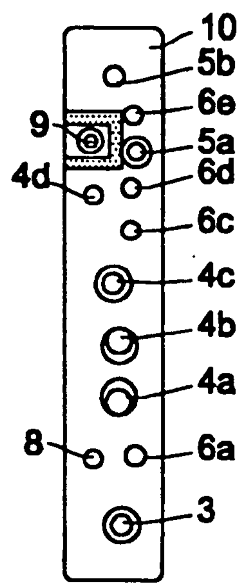


Fig. 5

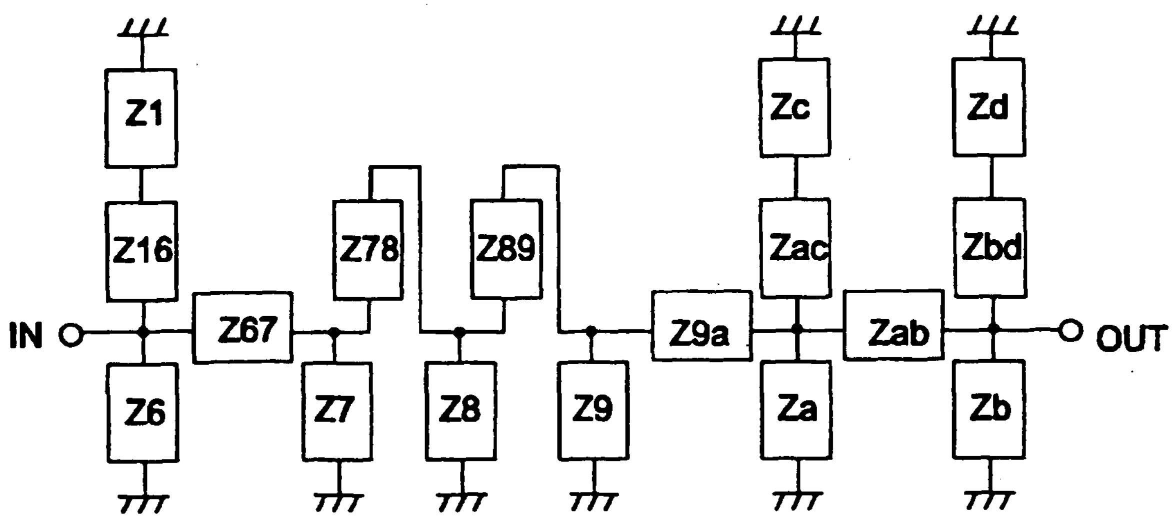


Fig. 6D

Fig. 6B

Fig. 6A

Fig. 6C

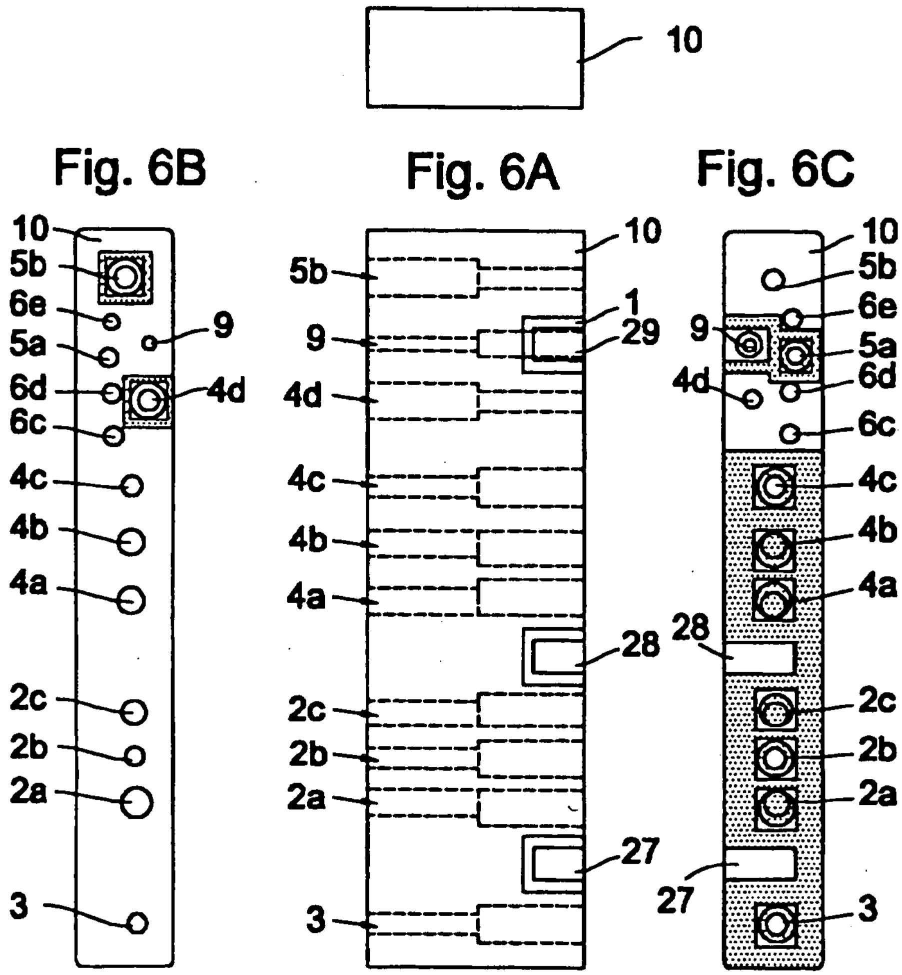


Fig. 7A

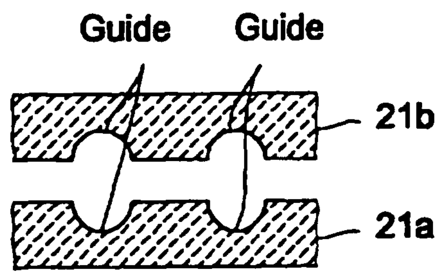


Fig. 7B

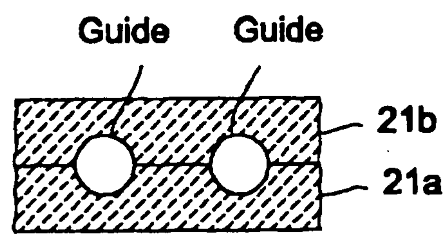


Fig. 8

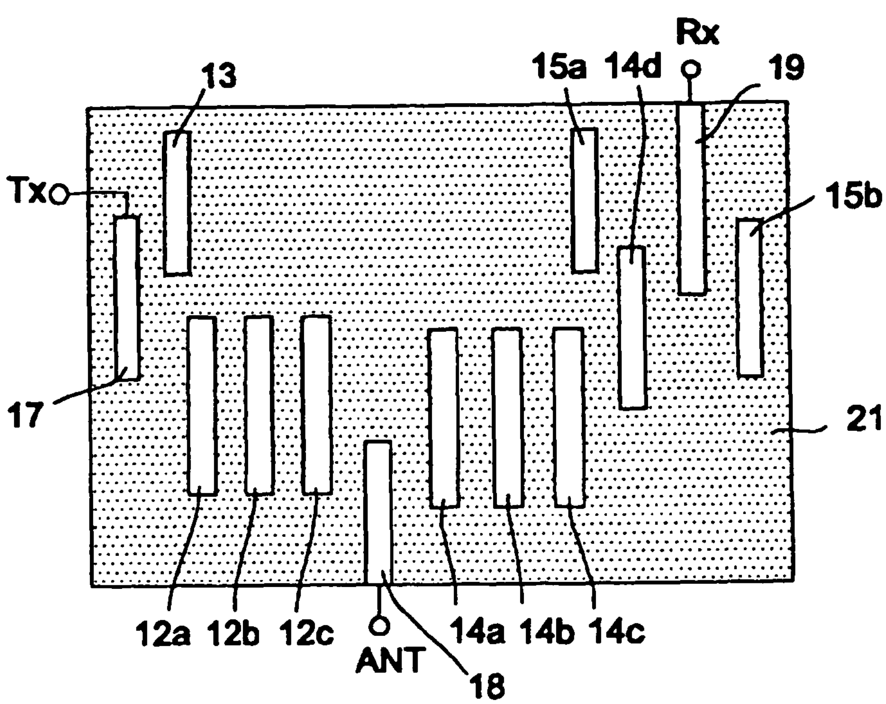


Fig. 9

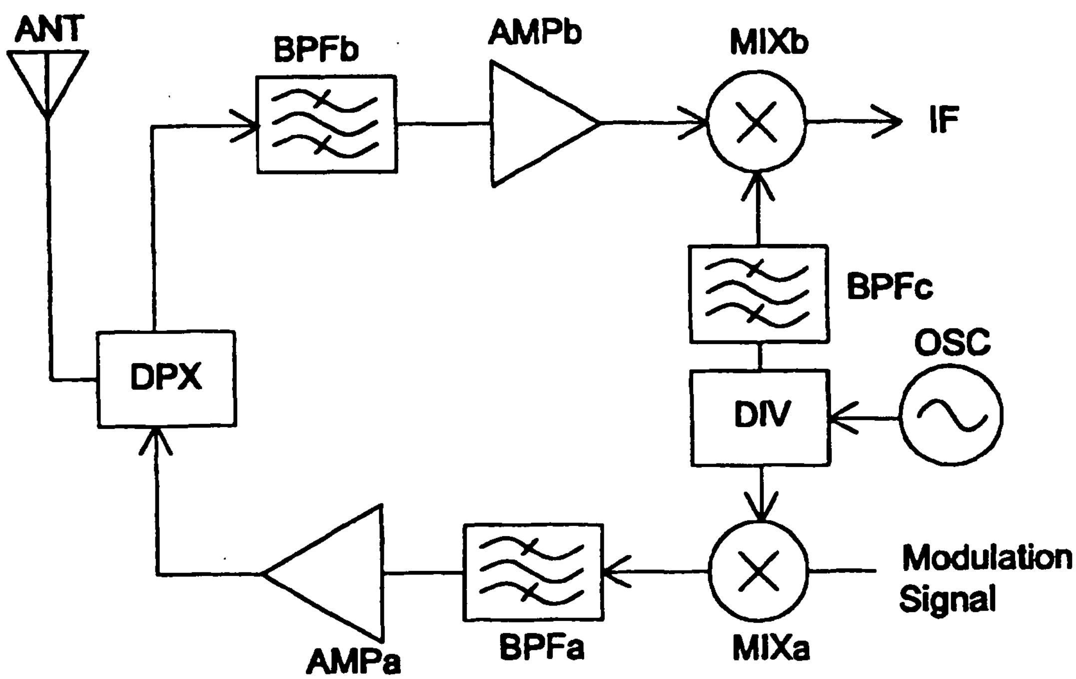

ANT
BPFb
AMPb
MIXb
IF
BPFc
OSC
DPX
DIV
Modulation Signal
AMPa
BPFa
MIXa

Fig. 10D

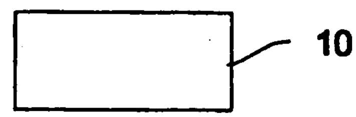


Fig. 10B
Prior Art

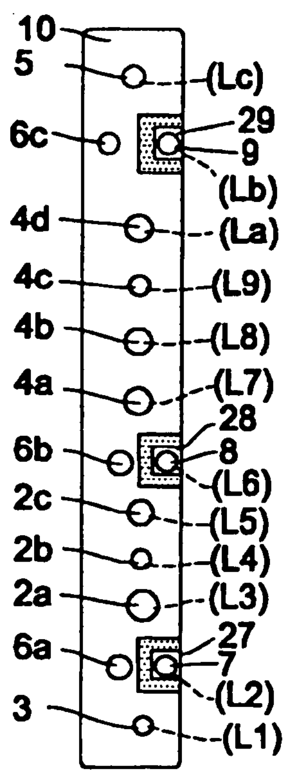


Fig. 10A
Prior Art

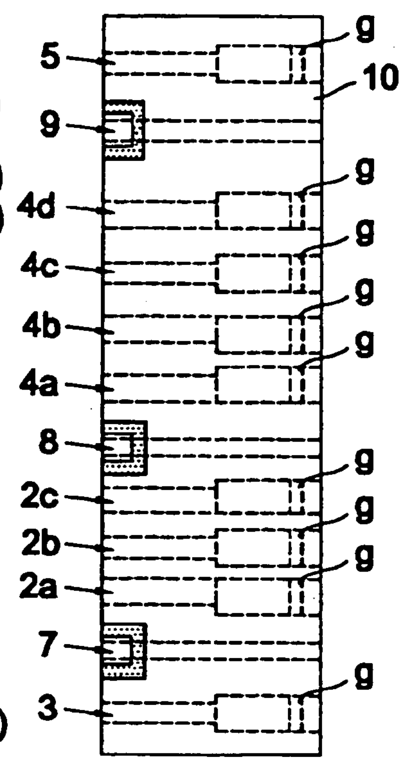


Fig. 10C
Prior Art

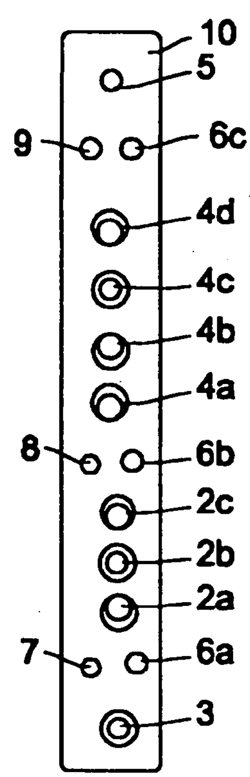
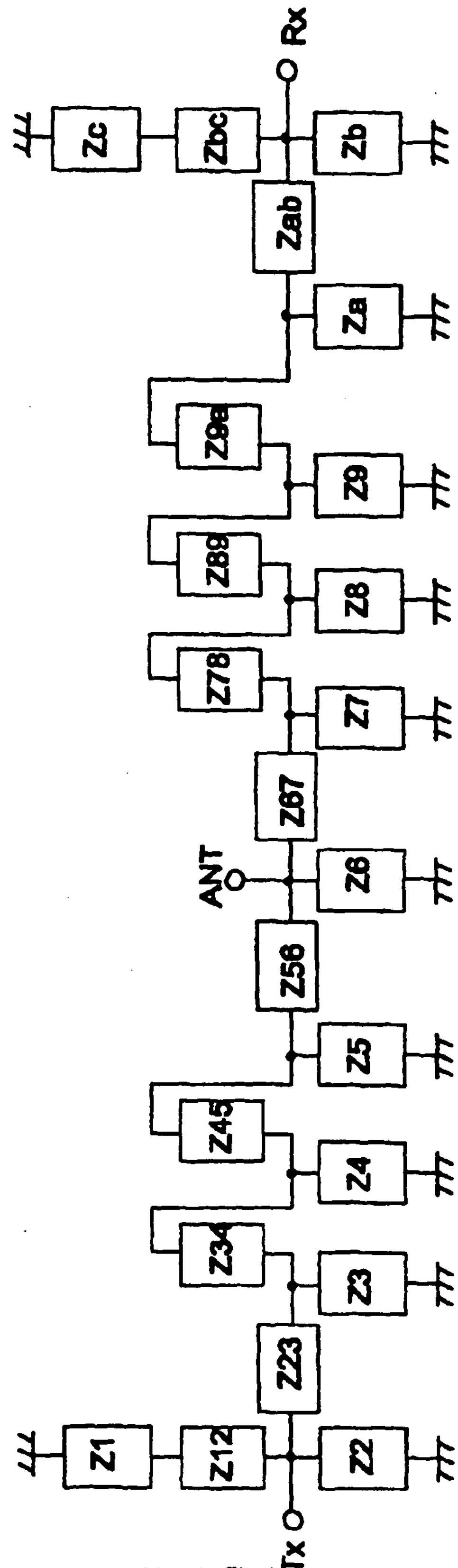


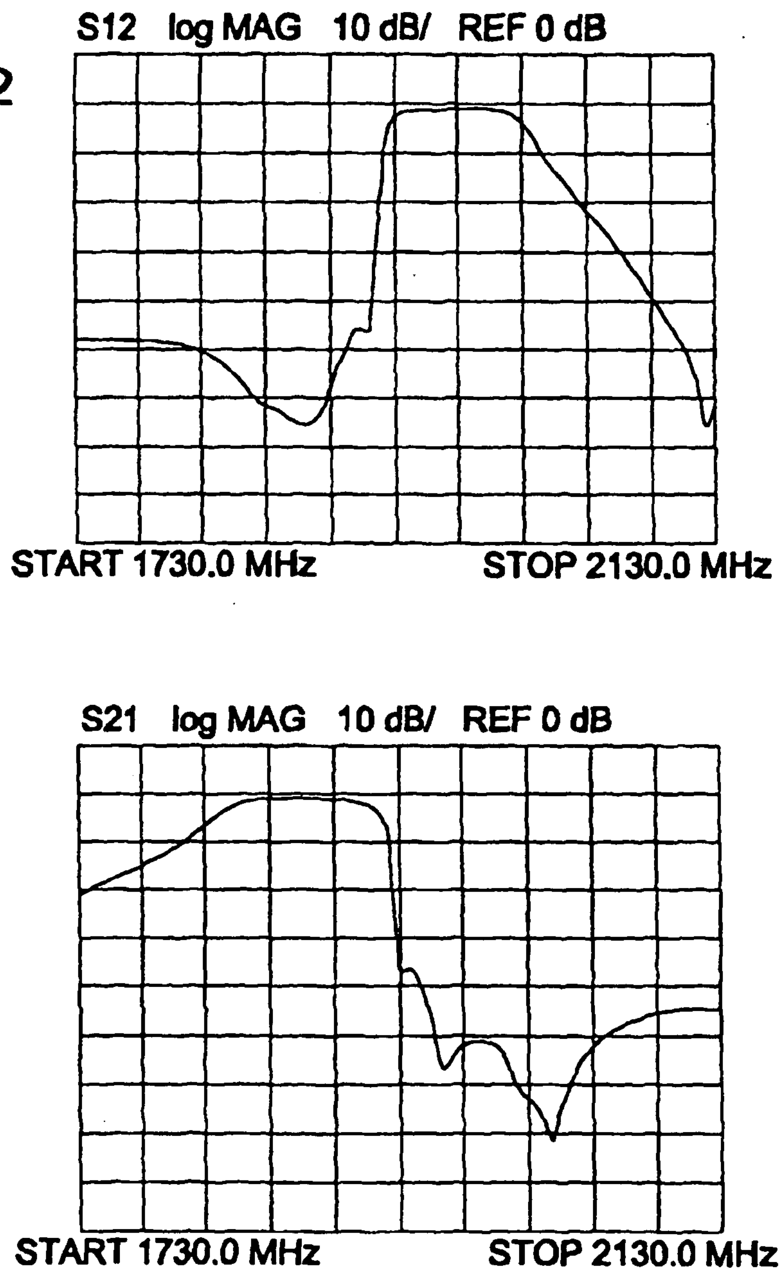
Fig. 11

Prior Art



Newly filed

Fig. 12
Prior Art



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 12 2518

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 0 840 390 A (MURATA MANUFACTURING CO. LTD.) 6 May 1998 (1998-05-06) * column 5, line 54 - column 7, line 15; figures 1A-D *	1-4	H01P1/205 H01P1/213
A	US 5 712 648 A (TSUJIGUCHI) 27 January 1998 (1998-01-27) * column 3, line 64 - column 5, line 15; figure 1 *	1-4	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
H01P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	7 February 2000	Den Otter, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document